

WHAT IS CLAIMED IS:

1. A computer-implemented method for modeling a wireless communications system, wherein the wireless communications system includes at least one transmitter and at least one receiver located at a distance from the transmitter, the method comprising:

5 (a) modeling, in the computer, a radio frequency (RF) signal's propagation between the transmitter and the receiver;

(b) determining, in the computer, an effect from at least one body of water residing between the transmitter and the receiver on the modeled radio frequency (RF) signal's propagation; and

10 (c) outputting, from the computer, a signal strength value for the modeled RF signal based on the determined effect from the body of water residing between the transmitter and receiver.

2. The method of claim 1, wherein the determining step comprises using line-of-sight calculations to determine the RF signal's strength and the effect from the body of water on the RF signal's strength.

3. The method of claim 1, wherein the RF signal is represented as a theoretical ray in the computer, and a reflection point of the ray is located where the ray intersects land and water.

4. The method of claim 1, wherein the determining step comprises predicting the RF signal's propagation in a first case where the receiver is visible to the transmitter.

25 5. The method of claim 4, wherein the predicting step is affected if the body of water is detected along a straight-line path from the transmitter to the receiver.

6. The method of claim 1, wherein the determining step comprises predicting the RF signal's propagation in a second case where the receiver is not visible to the transmitter.

7. The method of claim 6, wherein the predicting step is affected if the body of water is detected along a straight-line path from the transmitter to the receiver.

5 8. The method of claim 1, wherein the determining step comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is on the body of water, and the transmitter's antenna height above average mean sea level is less than or equal to the receiver's antenna height, then calculating the signal strength according to the following:

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$$\text{Signal} = \text{OAL} + 6 \text{ dB}$$

wherein OAL is an Open Area Loss:

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$$\text{OAL} = -49 - 43.5 * \log_{10} (\text{D in feet} / 5280)$$

and D is a distance between the transmitter and the receiver.

9. The method of claim 1, wherein the determining step comprises:
20 if the receiver is line-of-sight visible to the transmitter, the receiver is on the body of water, and the transmitter's antenna height above average mean sea level is greater than the receiver's antenna height, then calculating the signal strength according to the following:

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$$\text{Signal} = \text{OAL} + 20 \log (\text{TxHt} - \text{MoHt} / \text{HtAGL})$$

wherein OAL is an Open Area Loss:

$$\text{OAL} = -49 - 43.5 * \log_{10} (\text{D in feet} / 5280)$$

TxHt is the transmitter's antenna height above average mean sea level, MoHt is the receiver's antenna height, and HtAGL is the transmitter's antenna elevation above ground level, and D is a distance between the transmitter and the receiver.

- 5 10. The method of claim 1, wherein the determining step comprises:
if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the
body of water, then calculating the signal strength according to the following:

$$\text{Signal} = \text{OAL} + \text{Shadow Loss}$$

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wherein OAL is an Open Area Loss:

$$\text{OAL} = -49 - 43.5 * \log_{10} (D \text{ in feet} / 5280)$$

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D is a distance between the transmitter and the receiver, and the Shadow Loss is a loss due to knife-edge diffraction around obstacles.

11. The method of claim 1, wherein the determining step comprises:
if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the
20 body of water, then calculating the signal strength according to a basic Lee model.

12. The method of claim 1, wherein the determining step comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is not on the
body of water, the body of water is located between the transmitter and the receiver, and the
25 paths of the RF signals reflected by land and the paths of the RF signals reflected by the
body of water are not blocked, then calculating the signal strength according to the
following:

$$\text{Signal} = 46 - 20 \log (4 \pi D / W)$$

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wherein D is a distance between the transmitter and the receiver, and W is a wavelength of the RF signal.

13. The method of claim 1, wherein the determining step comprises:

5 if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land and the paths of the RF signals reflected by the body of water are both blocked from the receiver, then calculating the signal strength according to the following:

- 10 (i) find Shadow Loss for a point that blocks the receiver from the RF signals reflected by land, and
(ii) $\text{Signal} = \text{Path Loss} + \text{Shadow Loss}$

wherein the Shadow Loss is that loss due to knife-edge diffraction around obstacles.

14. The method of claim 1, wherein the determining step comprises:

15 if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land are blocked from the receiver and the paths of the RF signals reflected by the body of water are not blocked from the receiver, then calculating
20 the signal strength using the basic Lee model.

15. The method of claim 1, wherein the determining step comprises:

if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the
25 paths of the RF signals reflected by land are not blocked from the receiver and the paths of the RF signals reflected by the body of water are blocked from the receiver, then calculating the signal strength using a basic Lee model.

16. An article of manufacture embodying logic for modeling a wireless

30 communications system, wherein the wireless communications system includes at least one

transmitter and at least one receiver located at a distance from the transmitter, the logic comprising:

(a) modeling, in a computer, a radio frequency (RF) signal's propagation between the transmitter and the receiver;

5 (b) determining, in the computer, an effect from at least one body of water residing between the transmitter and the receiver on the modeled radio frequency (RF) signal's propagation; and

(c) outputting, from the computer, a signal strength value for the modeled RF signal based on the determined effect from the body of water residing between the transmitter and
10 receiver.

17. The article of manufacture of claim 16, wherein the determining step comprises using line-of-sight calculations to determine the RF signal's strength and the effect from the body of water on the RF signal's strength.

15 18. The article of manufacture of claim 16, wherein the RF signal is represented as a theoretical ray in the computer, and a reflection point of the ray is located where the ray intersects land and water.

20 19. The article of manufacture of claim 16, wherein the determining step comprises predicting the RF signal's propagation in a first case where the receiver is visible to the transmitter.

25 20. The article of manufacture of claim 19, wherein the predicting step is affected if the body of water is detected along a straight-line path from the transmitter to the receiver.

30 21. The article of manufacture of claim 16, wherein the determining step comprises predicting the RF signal's propagation in a second case where the receiver is not visible to the transmitter.

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$$\begin{array}{ccccccc} \mathbb{R}^{n_1 \times n_1} & \mathbb{R}^{n_1 \times n_2} & \mathbb{R}^{n_1 \times n_3} & \mathbb{R}^{n_2 \times n_2} & \mathbb{R}^{n_2 \times n_3} & \mathbb{R}^{n_3 \times n_3} & \mathbb{R}^{n_3 \times n_4} \\ \mathbb{R}^{n_1 \times n_2} & \mathbb{R}^{n_2 \times n_2} & \mathbb{R}^{n_2 \times n_3} & \mathbb{R}^{n_3 \times n_3} & \mathbb{R}^{n_3 \times n_4} & \mathbb{R}^{n_4 \times n_4} & \mathbb{R}^{n_4 \times n_5} \\ \mathbb{R}^{n_1 \times n_3} & \mathbb{R}^{n_2 \times n_3} & \mathbb{R}^{n_3 \times n_3} & \mathbb{R}^{n_3 \times n_4} & \mathbb{R}^{n_4 \times n_4} & \mathbb{R}^{n_4 \times n_5} & \mathbb{R}^{n_5 \times n_5} \end{array}$$

15 wherein OAL is an Open Area Loss:

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$$OAL = -49 - 43.5 * \log_{10} (D \text{ in feet} / 5280)$$

5 TxHt is the transmitter's antenna height above average mean sea level, MoHt is the receiver's antenna height, and HtAGL is the transmitter's antenna elevation above ground level, and D is a distance between the transmitter and the receiver.

25. The article of manufacture of claim 16, wherein the determining step comprises:

10 if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the body of water, then calculating the signal strength according to the following:

$$\text{Signal} = OAL + \text{Shadow Loss}$$

wherein OAL is an Open Area Loss:

15

$$OAL = -49 - 43.5 * \log_{10} (D \text{ in feet} / 5280)$$

D is a distance between the transmitter and the receiver, and the Shadow Loss is a loss due to knife-edge diffraction around obstacles.

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26. The article of manufacture of claim 16, wherein the determining step comprises:

if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the body of water, then calculating the signal strength according to a basic Lee model.

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27. The article of manufacture of claim 16, wherein the determining step comprises:

30 if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land and the paths of the RF signals reflected by the

body of water are not blocked, then calculating the signal strength according to the following:

$$\text{Signal} = 46 - 20 \log (4 \pi D / W)$$

5

wherein D is a distance between the transmitter and the receiver, and W is a wavelength of the RF signal.

28. The article of manufacture of claim 16, wherein the determining step
10 comprises:

if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land and the paths of the RF signals reflected by the body of water are both blocked from the receiver, then calculating the signal strength
15 according to the following:

(i) find Shadow Loss for a point that blocks the receiver from the RF signals reflected by land, and

(ii) $\text{Signal} = \text{Path Loss} + \text{Shadow Loss}$

wherein the Shadow Loss is that loss due to knife-edge diffraction around obstacles.

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29. The article of manufacture of claim 16, wherein the determining step comprises:

if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the
25 paths of the RF signals reflected by land are blocked from the receiver and the paths of the RF signals reflected by the body of water are not blocked from the receiver, then calculating the signal strength using the basic Lee model.

30. The article of manufacture of claim 16, wherein the determining step
30 comprises:

if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land are not blocked from the receiver and the paths of the RF signals reflected by the body of water are blocked from the receiver, then calculating the signal strength using a basic Lee model.

31. A computer-implemented system for modeling a wireless communications system, wherein the wireless communications system includes at least one transmitter and at least one receiver located at a distance from the transmitter, comprising:

10 (a) a computer;

(b) means, performed by the computer, for modeling a radio frequency (RF) signal's propagation between the transmitter and the receiver;

(c) means, performed by the computer, for determining an effect from at least one body of water residing between the transmitter and the receiver on the modeled radio frequency (RF) signal's propagation; and

(d) means, performed by the computer, for outputting a signal strength value for the modeled RF signal based on the determined effect from the body of water residing between the transmitter and receiver.

32. The system of claim 31, wherein the means for determining comprises means for using line-of-sight calculations to determine the RF signal's strength and the effect from the body of water on the RF signal's strength.

33. The system of claim 31, wherein the RF signal is represented as a theoretical ray in the computer, and a reflection point of the ray is located where the ray intersects land and water.

34. The system of claim 31, wherein the means for determining comprises means for predicting the RF signal's propagation in a first case where the receiver is visible to the transmitter.

35. The system of claim 34, wherein the means for predicting is affected if the body of water is detected along a straight-line path from the transmitter to the receiver.

5 36. The system of claim 31, wherein the means for determining comprises means for predicting the RF signal's propagation in a second case where the receiver is not visible to the transmitter.

10 37. The system of claim 36, wherein the means for predicting is affected if the body of water is detected along a straight-line path from the transmitter to the receiver.

38. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is on the body of water, and the transmitter's antenna height above average mean sea level is less than or equal
15 to the receiver's antenna height, then calculating the signal strength according to the following:

$$\text{Signal} = \text{OAL} + 6 \text{ dB}$$

20 wherein OAL is an Open Area Loss:

$$\text{OAL} = -49 - 43.5 * \log_{10} (\text{D in feet} / 5280)$$

25 and D is a distance between the transmitter and the receiver.

39. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is on the body of water, and the transmitter's antenna height above average mean sea level is greater than the receiver's antenna height, then calculating the signal strength according to the following:

30

$$\text{Signal} = \text{OAL} + 20 \log (\text{TxHt} - \text{MoHt} / \text{HtAGL})$$

wherein OAL is an Open Area Loss:

5 $\text{OAL} = -49 - 43.5 * \log_{10} (\text{D in feet} / 5280)$

TxHt is the transmitter's antenna height above average mean sea level, MoHt is the receiver's antenna height, and HtAGL is the transmitter's antenna elevation above ground level, and D is a distance between the transmitter and the receiver.

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40. The system of claim 31, wherein the means for determining comprises:
if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the body of water, then calculating the signal strength according to the following:

15 $\text{Signal} = \text{OAL} + \text{Shadow Loss}$

wherein OAL is an Open Area Loss:

$$\text{OAL} = -49 - 43.5 * \log_{10} (\text{D in feet} / 5280)$$

20

D is a distance between the transmitter and the receiver, and the Shadow Loss is a loss due to knife-edge diffraction around obstacles.

41. The system of claim 31, wherein the means for determining comprises:
25 if the receiver is not line-of-sight visible to the transmitter, and the receiver is on the body of water, then calculating the signal strength according to a basic Lee model.

42. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is not on the
30 body of water, the body of water is located between the transmitter and the receiver, and the

paths of the RF signals reflected by land and the paths of the RF signals reflected by the body of water are not blocked, then calculating the signal strength according to the following:

5
$$\text{Signal} = 46 - 20 \log (4 \pi D / W)$$

wherein D is a distance between the transmitter and the receiver, and W is a wavelength of the RF signal.

10 43. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land and the paths of the RF signals reflected by the body of water are both blocked from the receiver, then calculating the signal strength
15 according to the following:

(i) find Shadow Loss for a point that blocks the receiver from the RF signals reflected by land, and

(ii) $\text{Signal} = \text{Path Loss} + \text{Shadow Loss}$

wherein the Shadow Loss is that loss due to knife-edge diffraction around obstacles.

20 44. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is not on the body of water, the body of water is located between the transmitter and the receiver, and the paths of the RF signals reflected by land are blocked from the receiver and the paths of the
25 RF signals reflected by the body of water are not blocked from the receiver, then calculating the signal strength using the basic Lee model.

45. The system of claim 31, wherein the means for determining comprises:
if the receiver is line-of-sight visible to the transmitter, the receiver is not on the
30 body of water, the body of water is located between the transmitter and the receiver, and the

paths of the RF signals reflected by land are not blocked from the receiver and the paths of the RF signals reflected by the body of water are blocked from the receiver, then calculating the signal strength using a basic Lee model.

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